

compounds such as pigments, rust inhibitors, surfactants, defoamers, and the like. The compounds of Al, etc. may be aluminum hydroxide and aluminum oxide. The inorganic compounds are preferably inorganic pigments such as colloidal silica, carbon black, barium sulfate, titania, and alumina. The rust inhibitors may be aliphatic amines which are reducing agents, or ethylenediaminetetraacetic acids (EDTA) which are chelators. The surfactants are preferably nonionic surfactants, and more preferably acetylene glycol-based surfactants which are less foamable and have high wettability improving effect. The acetylene glycol-based surfactants are more preferably obtained by adding ethylene oxide to acetylene glycol. The defoamers are preferably silicone-based defoamers or acetylene glycol-based defoamers.

**[0051]** The total content of the additives in the composition is not particularly limited. The total content of the additives is preferably 20 mass % or less and more preferably 10 mass % or less with respect to the total solid content of the composition. If the total content of the additives is 20 mass % or less, there is no adverse effect. The lower limit of the total content of the additives is not particularly limited, and may be determined as appropriate depending on the additives used. For example, the total content of the additives may be 0.1 mass % or more or 1 mass % or more with respect to the total solid content of the composition. Although As, Bi, Cd, and Pb can be added to the composition, it is environmentally preferable not to add them.

**[0052]** The composition of the bond-type insulating coating obtained in the disclosure is the same as that of the solids of the composition used to form the coating.

**[0053]** (Baking)

**[0054]** The bond-type insulating coating may be baked using any of various known heating methods such as hot-air heating, infrared heating, and induction heating. The end-point steel sheet temperature in the baking treatment is preferably 150° C. or more and 350° C. or less, and more preferably 150° C. or more and 200° C. or less. If the end-point steel sheet temperature is 150° C. or more, the resulting coating is not excessively soft, so that the coiled steel strips are kept from sticking to each other and increasing the operation load in uncoiling (unwinding). An end-point steel sheet temperature of 350° C. or less is preferable because part of the linking groups which contribute to the reaction in the coating remains without linking and as a result desired shear bond strength develops when the stacked electrical steel sheet is formed. The time to reach the end-point steel sheet temperature may be 1 second or more and 100 seconds or less. If the time is 1 second or more, baking is sufficient, and the coating will not remain in liquid state. If the time is 100 seconds or less, the baking step does not take long, and so a decrease in manufacturing efficiency is prevented.

**[0055]** (Stacking)

**[0056]** A plurality of electrical steel sheet for stacking after the baking treatment is stacked. The number of steel sheets stacked is not limited. However, a smaller number of steel sheets requires a larger number of times punching is performed and leads to press mold wearing or lower manufacturing efficiency, whereas a larger number of steel sheets leads to lower workability and formability of the stacked electrical steel sheet. Accordingly, the number of steel sheets stacked is preferably 2 or more and 10 or less, and more preferably 3 or more and 8 or less.

**[0057]** (Heating and Pressing)

**[0058]** In the heating and pressing step, the electrical steel sheets for stacking stacked in the stacking step are heated and pressed simultaneously to be integrated. The heating and pressing treatment is preferably performed with a heating temperature of 100° C. to 250° C. and a pressure of 0.49 MPa to 4.90 MPa (=5 kgf/cm<sup>2</sup> to 50 kgf/cm<sup>2</sup>). The time for the heating and pressing treatment is preferably 5 minutes to 48 hours. By performing the heating and pressing step in the aforementioned heating temperature range, pressure range, and time range, complete hardening is achieved with no unreacted linking groups remaining in the coating, thus ensuring the bond strength of the stacked electrical steel sheet.

**[0059]** The total thickness of the stacked electrical steel sheet after the heating and pressing treatment is preferably 10 mm or more and less than 300 mm. If the total thickness is 10 mm or more, the effects of low iron loss and high magnetic flux density which are the features of the electrical steel sheets are sufficient. If the total thickness is less than 300 mm, the stacked material is manufactured easily in a heating and pressing jig, which improves the manufacturing efficiency of the stacked electrical steel sheet.

**[0060]** (Manufacture of Iron Core for Automotive Motor)

**[0061]** Stacked electrical steel sheets obtained in the aforementioned way are stacked through their bond-type insulating coatings, to manufacture an iron core for an automotive motor. The stacked electrical steel sheets thus stacked can be fixed using any method. Examples of the fixing method include caulking, bolting, fixing with other jigs, bonding by heating and pressing, welding, and any combination thereof. The use of the bond-type insulating coatings according to the disclosure complements the bond strength in the fixing method. Hence, the number of caulking points, the number of bolts, or the welded part can be reduced as compared with a method of fixing electrical steel sheets using conventional insulating coatings with poor bonding function unlike the bond-type insulating coatings according to the disclosure. This contributes to a more efficient iron core manufacturing process.

### Examples

**[0062]** The following describes the advantageous effects of the disclosure in detail based on examples, although the disclosure is not limited to these examples.

**[0063]** Each steel sheet with a size of 150 mm in width and 300 mm in length was cut from a non-oriented electrical steel sheet whose sheet thickness is shown in Table 1, and used as a sample. The electrical steel sheet as the sample was immersed in an ordinary-temperature sodium orthosilicate solution (0.8 mass % in concentration) for 30 seconds, and then washed with water and dried. Each type of composition was applied to the surface (both surfaces) of this pretreated sample using a roll coater, and baked in a hot-air baking oven. After this, the sample was allowed to cool at room temperature, thus obtaining an electrical steel sheet for stacking. The composition used, the end-point steel sheet temperature, the time to reach the temperature, and the film thickness after the baking are shown in Table 1. The resin, hardener, pigment, and additive used are shown respectively in Tables 2 to 5.

**[0064]** For each electrical steel sheet for stacking obtained as a result of the baking step, the Martens hardness and the logarithmic decrement peak temperature were measured,